PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : D21B 1/02, 1/14

A1

(11) International Publication Number: WO 94/16139

(43) International Publication Date: 21 July 1994 (21.07.94)

(21) International Application Number: PCT/SE93/01058

(22) International Filing Date: 8 December 1993 (08.12.93)

(30) Priority Data:
9203943-7 30 December 1992 (30.12.92) SE

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(81) Designated States: AU, BR, CA, FI, JP, KR, NO, NZ, PL, RU, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: A METHOD OF PRODUCING MECHANICAL AND CHEMI-MECHANICAL PULP

(57) Abstract

A method of producing mechanical and chemi-mechanical pulp with a yield above 85 % from lignocellulose-containing material for the manufacture of paper or board products. The material is subjected to mechanical processing in at least two steps. The material at its feed into the first step has a temperature below the softening temperature of lignin. When the material is fed into at least one subsequent processing step, it shall have a temperature above the softening temperature of lignin.

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A method of producing mechanical and chemi-mechanical pulp

This invention relates to the production of mechanical and chemi-mechanical pulp with a yield of above 85% from ligno-cellulose-containing material for the making of paper or board products.

Mechanical pulp (e.g. TMP) or chemi-mechanical pulp (e.g. CTMP) is today produced in several different process variations, where steamed chips are refined in disc refiners of various types. At the production of pulps for different printing papers or wrapping materials, of board type, the refining usually is carried out in one or more steps. The first step normally is pressurized, i.e. the refining takes place at temperatures exceeding 100°C, usually immediately below or at the so-called softening temperature (Tg) of the lignin. Heretofore, it was chosen to hold the pressure and temperature in subsequent refining steps on the same level as in the first refining step, or to carry out later refining steps in systems not pressurized, i.e. at a temperature lower than in the initial step, usually at the softening temperature of the lignin or below the same.

The softening temperature of the lignin, which has proved to be an important variable at the refining of chips in mechanical and chemi-mechanical pulp processes, has been determined in the most recent decades in a number of scientific investigations for a plurality of wood types concerned. At the investigations standard equipment and conventional measuring principles for the determination of viscoelastic parameters have been used. For wood, as for other viscoelastic materials, the softening temperature varies with the load frequency at the measurements. At a higher load frequency, the softening temperature increases. At the processing frequencies normally applied in refiners the softening temperature of coniferous wood was determined to be between 125°C and 145°C, while it proved to be somewhat

lower for our most usual hardwood types. The softening temperature can be shifted by the addition of different chemicals. It can be lowered, for example, after impregnation by usual lignin softening chemicals, of the type sulphite.

Relatively high total electric energy amounts are required for producing the aforementioned types of pulp. The production of pulp for newsprint from coniferous wood, for example, can require up to 2000kWh/ton pulp. In many studies carried out recently with the object of trying to lower the electric energy consumption in the TMP-process, it was found that the initial processing phase seemed to be quite essential for the total energy consumption in different process variants and for the character of the resulting pulp. This seems to apply in spite of the fact that only a small part of the total electric energy consumption in the refining process is used for the fiber separation proper, i.e. for the conversion from chips to free individual fibers (also called defibering).

A fiber separation energy-effective per se as a result of an effective thermal or chemical softening of the chip areas rich in lignin, however, does not prove to be a garanty that the total energy consumption will be low. On the contrary, it was proved that TMP-process variants, which were initiated with a mild fiber separation poor in energy, often require a high total energy input.

This circumstance seems to be caused by the fact, that mildly separated but unprocessed fibers, which were obtained by carrying out the defibering at temperatures above the softening temperature of the wood lignin, are difficult to fibrillate during the continued working in the refining process. This fibrillation is necessary for increasing the flexibility of the fibers to a desired level and bringing about the fine material characterizing a good TMP-quality. An intensive

processing below the softening temperature of the wood lignin initially and during the continued refining process, on the other hand, easily leads to a deterioration of the long fiber content and thereby of the strength properties of the pulp. This is in many cases unacceptable from a quality point of view. A decrease in the energy consumption from an established level in the TMP-process, as a rule, has been associated with a deterioration of certain quality properties of the resulting pulp, for example lower long fiber contant, lower tear strength, lower tensile strength and higher shives content. The present high energy consumption in the TMP- and CTMP-process, therefore, has been necessary for achieving the desired pulp properties.

It was now found by surprise, that it is possible to combine low energy consumption in a mechanical or chemi-mechanical pulp making process with maintained quality properties. The present invention relates to such a method, where the mechanical processing, for example refining, takes place in at least two steps. According to the invention, the material at its feed into the first processing step has a temperature below the softening temperature of the lignin, and at its feed into at least one subsequent processing step has a temperature exceeding the softening temperature of the lignin. The invention is described in greater detail in the following, with reference to some expedient embodiments and examples with associated Figures 1-8..

In a TMP-process according to the invention, refining takes place in at least two steps. In the first step the chips are fed into the refiner at a temperature below the softening temperature of the lignin and then are processed under relatively intensive conditions, for example in a double-disc refiner with a speed of at least 1200 rpm or in a single-disc refiner with high relative speed between the refiner discs (at least 1800 rpm, preferably at least 2400 rpm). The energy input

in the first step is chosen to be on such a low level, that the long fiber content of the pulp which a.o. yields the potential for the later strength development at the refining, is not deteriorated appreciably. The freenes (CSF) of the pulp after the first step, therefore, shall be high, preferably $>$ 500 ml. A subsequent refining step is carried out under conditions where the lignin of the fiber material is well softened. The fiber material then is fed into the refiner at a temperature exceeding the softening temperature of the lignin. In cases when the material consists of coniferous wood not treated with chemicals, the temperature should exceed 150°C, suitably 160°C and preferably 170°C. When the material is treated with chemicals, the temperature should exceed 135°C, suitably 150°C and preferably 160°C. As regards an upper temperature limit, temperatures over 200°C should be avoided, a.o. with regard to dark colouring of the fiber material. The processing frequency preferably can be high (relative speed at least 2400 rpm) at the processing of the well-softened fiber material, which has proved especially favourable from an energy point of view.

The temperature difference between the temperatures of the material at its feed into the first and, respectively, a subsequent processing step should be at least 15°C, suitably at least 25°C and preferably at least 35°C.

In a process according to the invention fractures and fracture indications in the material initially are guided to layers in the fiber wall not rich in lignin. During the final refining the known fact then can be utilized, that the fiber material can be separated with low energy inputs in areas rich in lignin at temperatures above the softening temperature of the wood lignin. The fractures initially having been guided to areas not rich in lignin, it is thereby avoided to obtain a fiber material with only lignin-covered surfaces which are difficult to fibrillate. This has previously been the great

problem when it was tried to utilize refining temperatures above the softening temperature of the lignin at the production of mechanical pulps for printing paper or board products. Fine material from areas between the initial fracture zone and the middle lamina of the fiber rich in lignin also is easily released at temperatures above the softening temperature of the lignin in the later refining step, which can explain the low total energy consumption to a certain freeness (CSF) in this process step and in the entire process according to the invention. The production of fine material otherwise is the most energy requiring part of the mechanical pulp process using conventional technique.

EXAMPLE

Thermomechanical pulp from spruce chips was produced after refining in two steps in a 20" single-disc refiner of a well-equipped test plant. The first refining step (defibering) was carried out after preheating the chips at 115°C for about 3 minutes, i.e. at a temperature below the softening temperature of the lignin. The refiner was driven by a 3000 rpm motor, in order to ensure that the initial defibering should not take place under too mild conditions. The effect input in the first step was 640 kWh/t, which yielded a pulp with freeness (CSF) 518 ml. In the second refining step the conditions were varied according to the following Table:

3000 ≠ 1500 or 3100

Test	Preheating time min	Refining temperature °C x)	Motor speed rpm
A	about 1	115 (< Tg)	1500
B	" 1	160 (> Tg)	1500
C	" 1	160 (> Tg)	3000
D	" 1	170 (> Tg)	3000

x) Temperature at preheating and at feed into the refiner

The effect of the varying conditions is shown in Figs. 1-6 where the most essential pulp properties have been valued, and are commented on as follows:

Fig. 1
shows freeness as a function of energy consumption. It appears that by carrying out the second refining step at temperatures above the softening temperature of the lignin the energy input at refining to a certain freeness can be reduced considerably compared to conventional second step refining at temperatures below the softening temperature of the lignin (compare Tests A and B).The energy reduction will be still greater when, in addition, the speed is increased from 1500 to 3000 rpm (compare Test B with Tests C and D).

Fig. 2
shows the shives content as a function of the energy consumption. It appears that second step refining at temperatures above the softening temperature of the lignin yields a clearly lower shives content at a certain energy input than refining at a temperature below the softening temperature of the lignin (compare Test A with Tests B-D). Also in this case the higher speed yields the most favourable values. This proves to be a further advantage by using the conditions according to the invention.

Fig. 3
shows the long fiber content as a function of freeness. It appears that the long fiber content of the pulp generally can be maintained all the way down to the freeness range 150-200 ml, in spite of the heavy energy reduction at refining according to the conditions of the invention.

Fig. 4
shows the tear index as a function of freeness. It appears that the tear index of the pulp can be maintained all the way down to the freeness range 150-200 ml, in spite of the large energy reduction at refining at the conditions of the invention.

Figs. 5 and 6
show the tensile index and, respectively, light scattering as a function of freeness. It appears that all tested pulps develop tensile index and, respectively, light scattering coefficient in a similar way when they are valued conventionally against freeness.

In parallel with the tests described and with reference thereto it also was investigated, how energy consumption and pulp quality are affected when a refining process contrary to the conditions of the invention was started with a refining step where the temperature at the feed to the first step refiner is higher than the softening temperature of the lignin. Also in this case the thermomechanical pulp was made from spruce chips after refining in two steps by single-disc refiners. The first refining step was carried out at temperatures above the softening temperature of the lignin in the same equipment which was used previously in the test. The conditions in the first refining step and the freeness after refining with a certain energy input are described in the following Table:

Test	Preheating time, min	Refining temp. °C x)	Motor speed rpm	Energy input kWh/t	Freeness ml
E	about 1	150 (> Tg)	3000	940	450
F	" 1	160 (>Tg)	1500	900	580
G	" 1	160 (>Tg)	3000	790	415

x) Temperature at preheating and feed into the refiner

In a second refining step which was carried out under atmospheric conditions in a 20" refiner, i.e. at temperatures below the softening temperature of lignin, the freeness was lowered to an interesting range for printing paper pulps. The refiner speed in this case was 1500 rpm.

The effect of the varying conditions on energy consumption and light scattering capacity appears from Figs. 7 and 8, which show freeness as a function of energy consumption and, respectively, light scattering as a function of freeness.

Fig. 7
shows that the energy consumption is considerably higher when the TMP-process is initiated with a refining step at a temperature above the softening temperature of lignin than that obtained with conditions according to the invention (compare Fig. 1).

Fig. 8
shows that the light scattering coefficient is considerably lower when the TMP-process is initiated with a refining step at temperatures above the softening temperature of lignin than that obtained with conditions according to the invention (compare Fig. 6). The pulps produced according to the invention, therefore, are clearly most suitable for use as printing paper pulps, where just the light scattering coefficient must be sufficiently high for achieving the desired optical properties.

The example described proves clearly, that mechanical pulp can be produced with the conditions of the invention at low energy consumption, at the same time as essential properties like shives content, long fiber content,tear strength, tensile strength and light scattering meet high requirements on this type of pulps. The energy consumption at the production of newsprint, for example, can be reduced by about 40% compared with conventional manufacturing methods.

In the process according to the invention, chemicals can be added advantageously after or during the first refining step, in order to avoid dark colouring at the high temperatures above the softening temperature of lignin in subsequent refining steps. The chemicals also can have a bleaching effect.

Examples of such chemicals are sodium sulphite, sodium bisulphite, sodium ditionite, peroxide etc.

According to the invention, the initial processing can be carried out, besides in refiners, also in grinders, compressing screws or other mechanical processing equipment.

In cases when a reject fraction separated from the processed material is subjected to additional mechanical processing, this reject with a temperature above the softening temperature of lignin shall be fed into at least one subsequent processing step.

The invention, of course, is not restricted to the examples shown, but can be varied within the scope of the invention idea.

Claims

1. A method of producing mechanical and chemi-mechanical pulp with a yield above 85% from lignocellulose-containing fiber material for the manufacture of paper or board products, which method comprises mechanical processing in at least two steps, characterized in that the material at its feed into the first processing step has a temperature below the softening temperature of lignin, and at its feed into at least one subsequent processing step has a temperature above the softening temperature of lignin.

2. A method as defined in claim 1, characterized in that the temperature difference between the temperatures of the material at its feed into the first step and at its feed into at least one subsequent step is at least 15°C, suitably at least 25°C and preferably at least 35°C.

3. A method as defined in claim 1 or 2, where the material consists of coniferous wood not treated with chemicals, characterized in that the temperature of the material at its feed into at least one subsequent step exceeds 150°C, suitably 160°C and preferably 170°C.

4. A method as defined in claim 1 or 2, where the material is treated with chemicals, characterized in that the temperature of the material at its feed into at least one subsequent step exceeds 135°C, suitably 150°C and preferably 160°C.

5. A method as defined in any one of the preceding claims, characterized in that the mechanical processing in at least one subsequent step is carried out by a refiner.

6. A method as defined in any one of the preceding claims, characterized in that all processing steps are carried out by refiners.

7. A method as defined in any one of the preceding claims, characterized in that a reject fraction separated from the mechanically processed material with a temperature above the softening temperature of lignin is fed into at least one subsequent processing step.

8. A method as defined in any one of the preceding claims, characterized in that the first processing step is carried out in a double-disc refiner with a speed of at least 1200 rpm or in a single-disc refiner with a speed of at least 1800 rpm, preferably at least 2400 rpm.

9. A method as defined in any one of the preceding claims, characterized in that at least one subsequent step is carried out in a refiner with a relative speed of at least 2400 rpm.

10. A method as defined in any one of the preceding claims, characterized in that chemicals maintaining brightness or bleaching chemicals, such as sodium sulphite, sodium bisulphite, sodium ditionite, peroxide etc. are added after or during the first processing step.

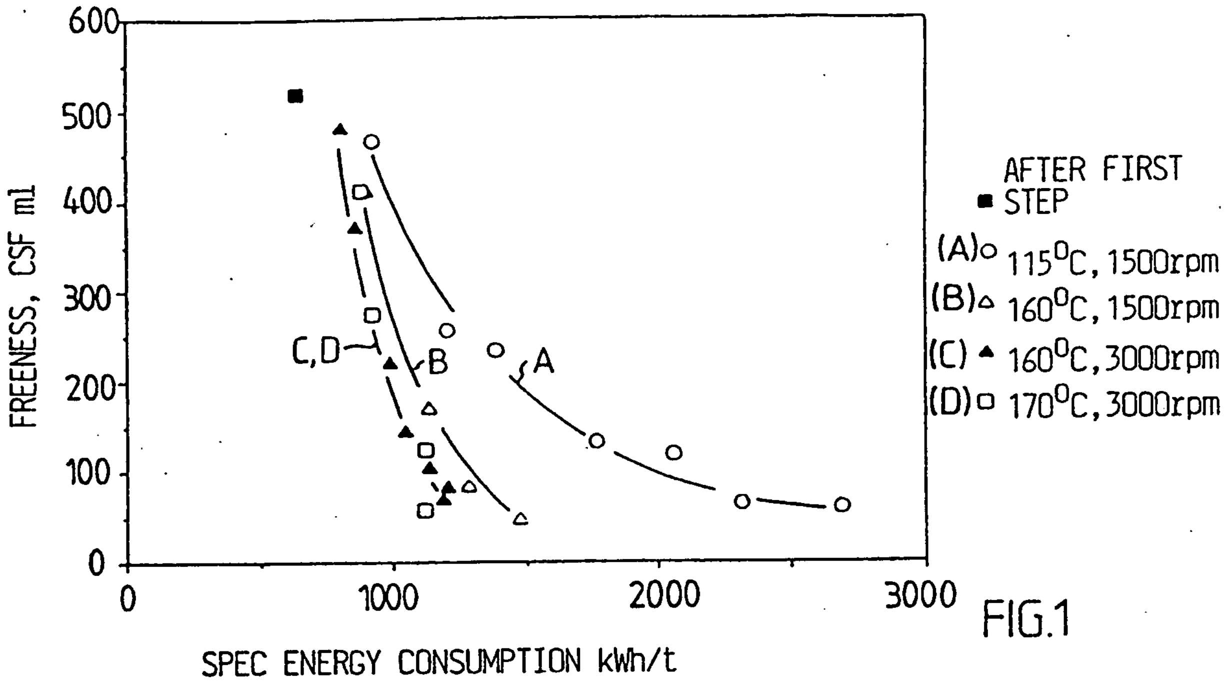
600
500
400
300
200
100
0
FREENESS, CSF ml
0
1000
2000
3000
SPEC ENERGY CONSUMPTION kWh/t
C,D
B
A
AFTER FIRST STEP
(A) 115°C, 1500rpm
(B) 160°C, 1500rpm
(C) 160°C, 3000rpm
(D) 170°C, 3000rpm

FIG.1

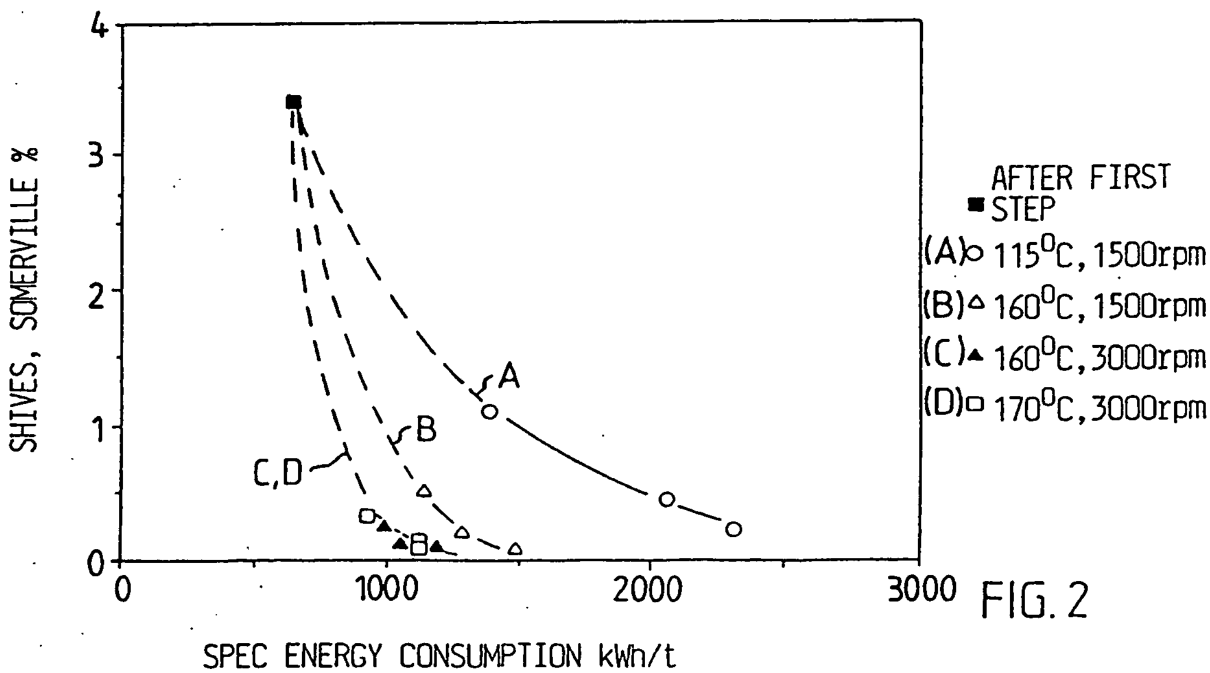
4
3
2
1
0
SHIVES, SOMERVILLE %
0
1000
2000
3000
SPEC ENERGY CONSUMPTION kWh/t
C,D
B
A
AFTER FIRST STEP
(A) 115°C, 1500rpm
(B) 160°C, 1500rpm
(C) 160°C, 3000rpm
(D) 170°C, 3000rpm

FIG. 2

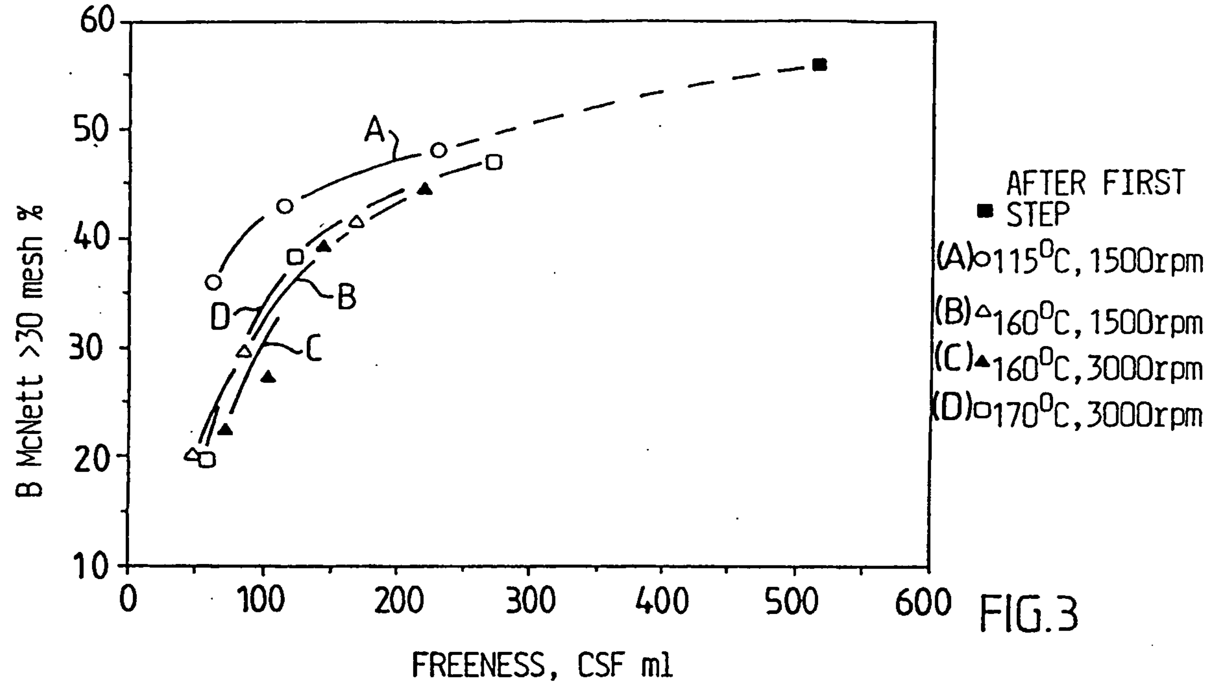
60
50
40
30
20
10
B McNett >30 mesh %
0
100
200
300
400
500
600
FREENESS, CSF ml
A
B
C
D
AFTER FIRST STEP
(A) 115°C, 1500rpm
(B) 160°C, 1500rpm
(C) 160°C, 3000rpm
(D) 170°C, 3000rpm

FIG.3

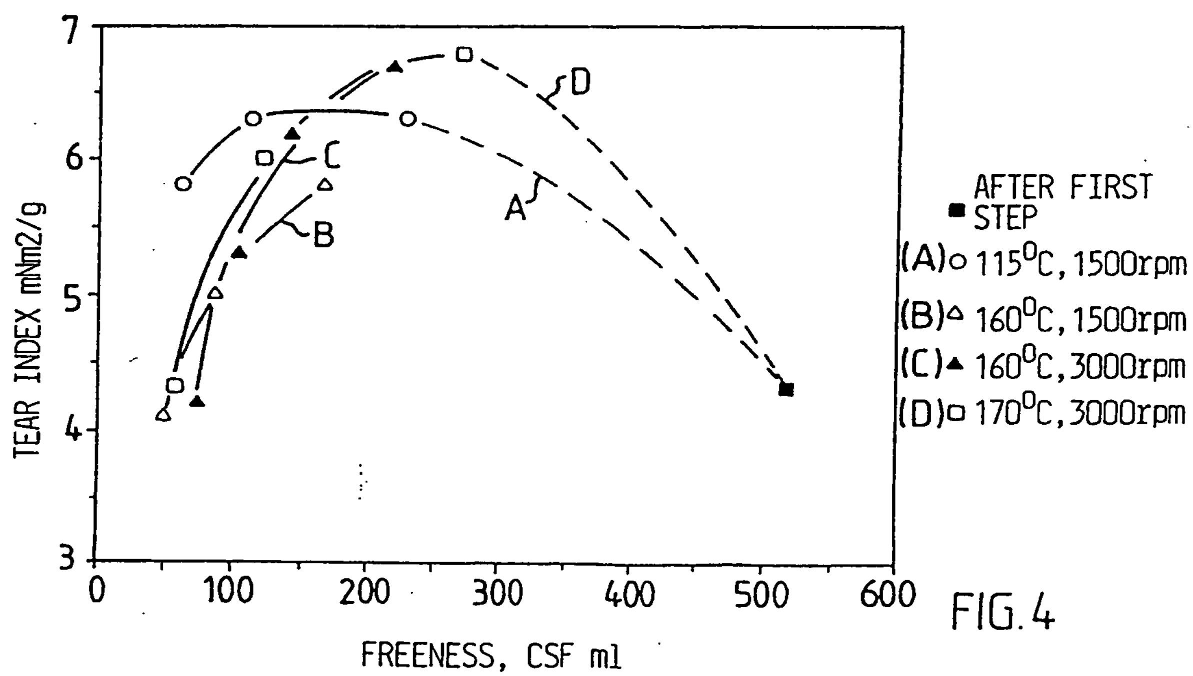
7
6
5
4
3
TEAR INDEX mNm2/g
0
100
200
300
400
500
600
FREENESS, CSF ml
A
B
C
D
AFTER FIRST STEP
(A) 115°C, 1500rpm
(B) 160°C, 1500rpm
(C) 160°C, 3000rpm
(D) 170°C, 3000rpm

FIG.4

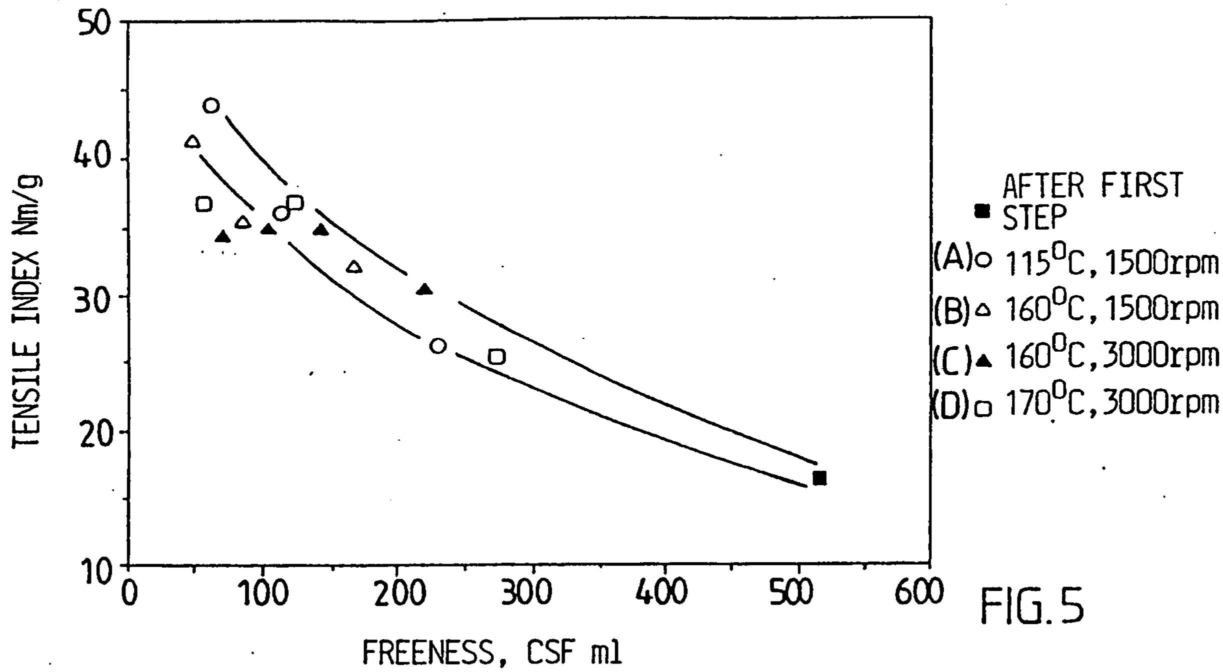
50
40
30
20
10
TENSILE INDEX Nm/g
0
100
200
300
400
500
600
FREENESS, CSF ml
AFTER FIRST STEP
(A) 115⁰C, 1500rpm
(B) 160⁰C, 1500rpm
(C) 160⁰C, 3000rpm
(D) 170⁰C, 3000rpm

FIG. 5

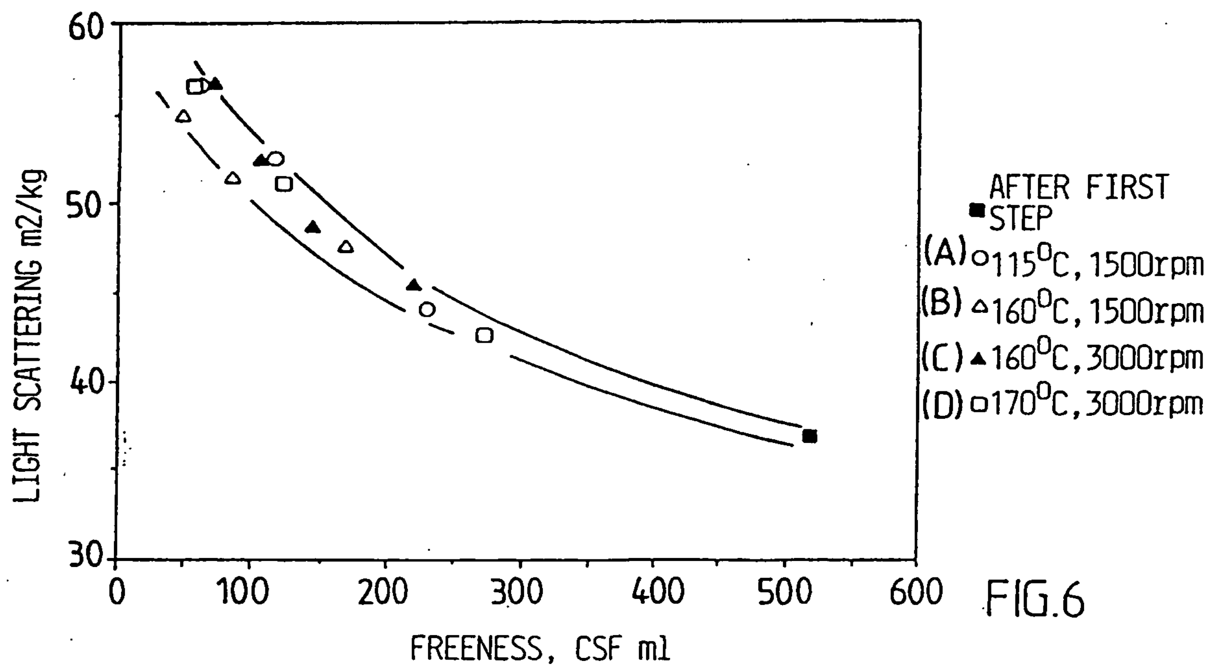
60
50
40
30
LIGHT SCATTERING m2/kg
0
100
200
300
400
500
600
FREENESS, CSF ml
AFTER FIRST STEP
(A) 115⁰C, 1500rpm
(B) 160⁰C, 1500rpm
(C) 160⁰C, 3000rpm
(D) 170⁰C, 3000rpm

FIG. 6

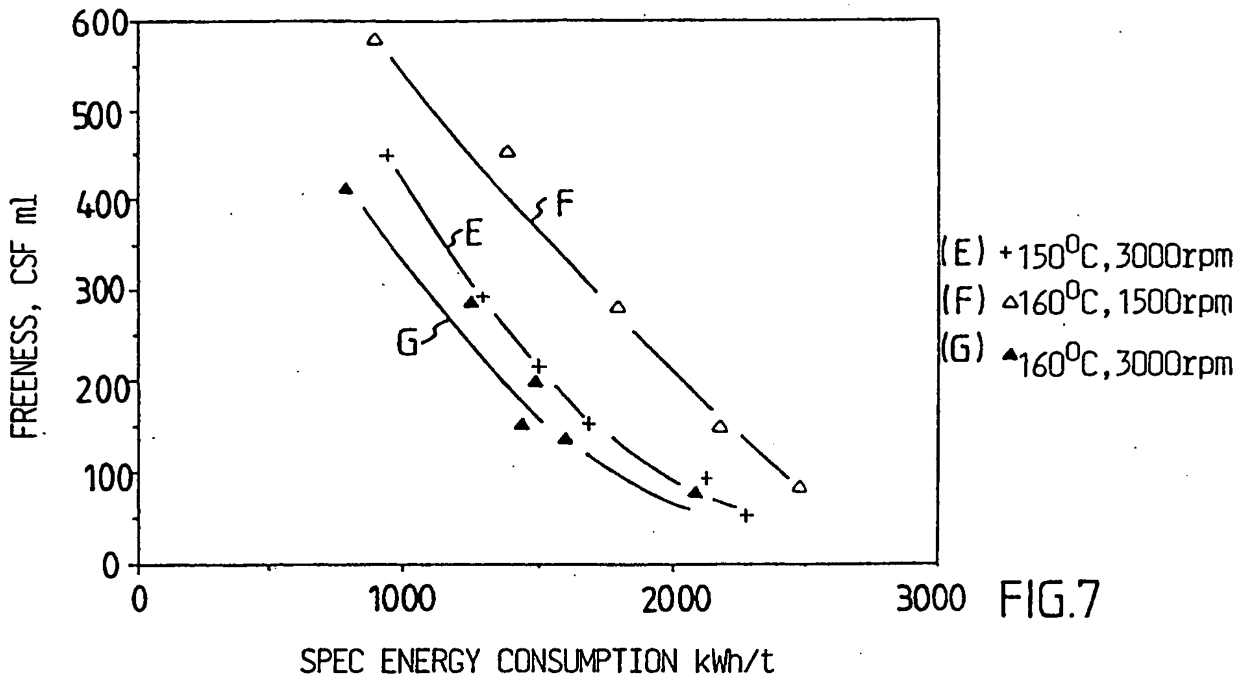
600
500
400
300
200
100
0
FREENESS, CSF ml
0
1000
2000
3000
SPEC ENERGY CONSUMPTION kWh/t
F
E
G
(E) +150°C,3000rpm
(F) △160°C,1500rpm
(G) ▲160°C,3000rpm

FIG.7

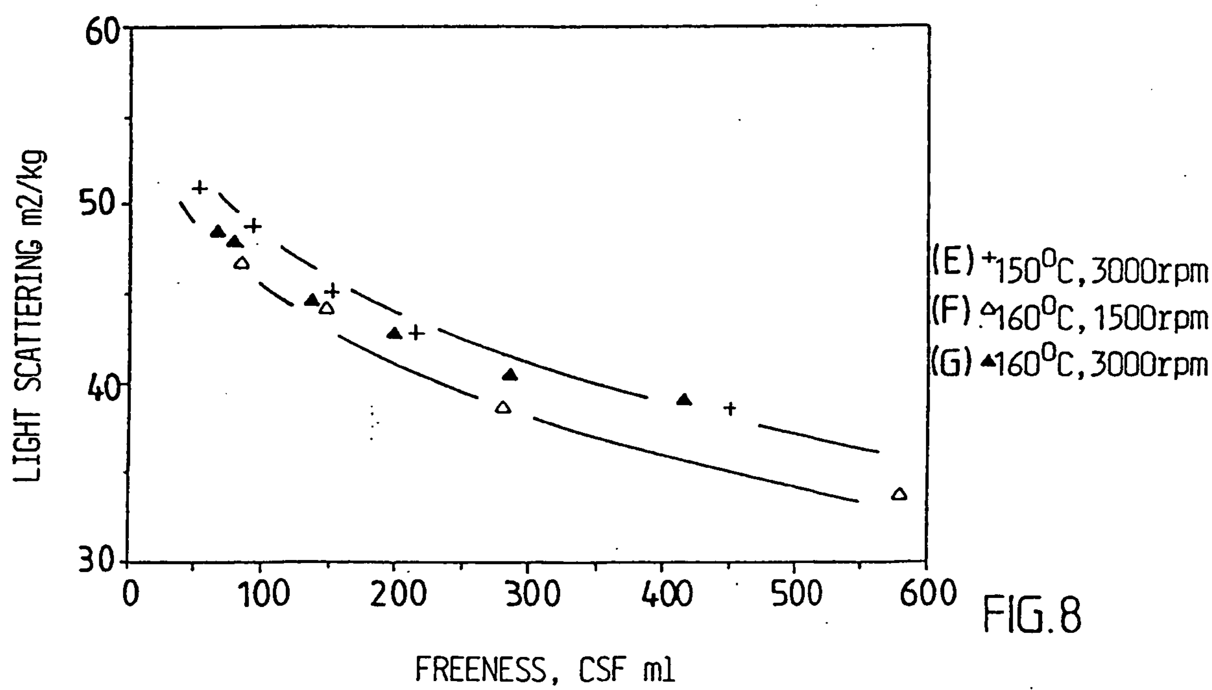
60
50
40
30
LIGHT SCATTERING m2/kg
0
100
200
300
400
500
600
FREENESS, CSF ml
(E) +150°C,3000rpm
(F) △160°C,1500rpm
(G) ▲160°C,3000rpm

FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 93/01058

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: D21B 1/02, D21B 1/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: D21B, D21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO, A1, 9112367 (SCA RESEARCH AB), 22 August 1991 (22.08.91), abstract --	1-10
A	SE, B, 303088 (DEFIBRATOR AB), 12 August 1968 (12.08.68), claims 1-4 -- --------	1-10

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Date of the actual completion of the international search	Date of mailing of the international search report
8 April 1994	13 -04- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Wiva Asplund Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

26/02/94

International application No.
PCT/SE 93/01058

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A1- 9112367	22/08/91	AU-A- 7327191	03/09/91
		EP-A- 0572388	08/12/93
SE-B- 303088	12/08/68	NONE	

Form PCT/ISA/210 (patent family annex) (July 1992)